Effect on tracking performance of increasing radii of MVTX layers to increase beam pipe clearance

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Introduction

The goal of this study was to evaluate the effect on tracking performance if the radius of the inner MVTX layer is increased from the value used by ALICE, so as to provide adequate clearance from the sPHENIX beam pipe.

This was tested by increasing the radius of all three MVTX layers by 1.5 mm, and comparing the tracking performance obtained with that to the performance obtained with the radii used by ALICE.

Note 1: Radius here refers to the distance from the center of the beam pipe to the center of the sensor.

Note 2: Before the study, Walt Sondheim and I discussed whether the MVTX geometry implemented in the simulation matches what is reflected in his drawing. We found that the parameters read from his drawing agreed at the 1% level with those used in the simulation code. Good.

The simulation

The nominal MVTX layer radii are set in the macro:

https://github.com/sPHENIX-Collaboration/macros/tree/master/macros/g4simulations/
G4_Svtx_maps_ladders+intt_ladders+tpc_40layer_KalmanPatRec.C

The construction of the detector geometry is done in the module:

https://github.com/sPHENIX-Collaboration/coresoftware/simulation/g4simulation/
/g4detectors/ PHG4MapsDetector

The stave description is imported from the ALICE simulation, captured in the file “ITS.gdml”. All that PHG4MapsDetector does is to place the staves in the sPHENIX detector with the requested nominal radius and tilt. It calculates the maximum number of staves that will fit at that radius, maintaining a minimum arc-length separation between staves, and then spaces them evenly in azimuth.

The simulation

The minimum spacing in arc length for the staves is the arc length between inner barrel staves that is inferred from “ITS.gdml”. It is a little more than 12.25 mm (average is ~ 12.3 mm) in all layers. Therefore a minimum arc length spacing of 12.25 mm is used in the code to automatically calculate how many staves should be used at a given radius.

For a small increase in radius, this automatically results in an appropriate increase in the azimuthal spacing between the staves.

For the existing simulation, the inner barrel layer radii obtained from “ITS.gdml” are:

maps_layer_radius[3] = {23.4, 31.5, 39.3}; // mm

The stave tilt (the tilt away from normal to the radial vector) is taken from the gdml file, and is 0.304 radians (17.4 degrees) for all three layers.

For the second tested configuration, the radii are increased by 1.5 mm and the tilts are kept the same at 17.4 degrees.

What is simulated?

The events consist of:

100 pions with
- Flat p_T distribution from 0.1 to 20.0 GeV/c
- $-1.0 < \eta < 1.0$
- Flat vertex distribution covering -5.0 cm < Z < 5.0 cm

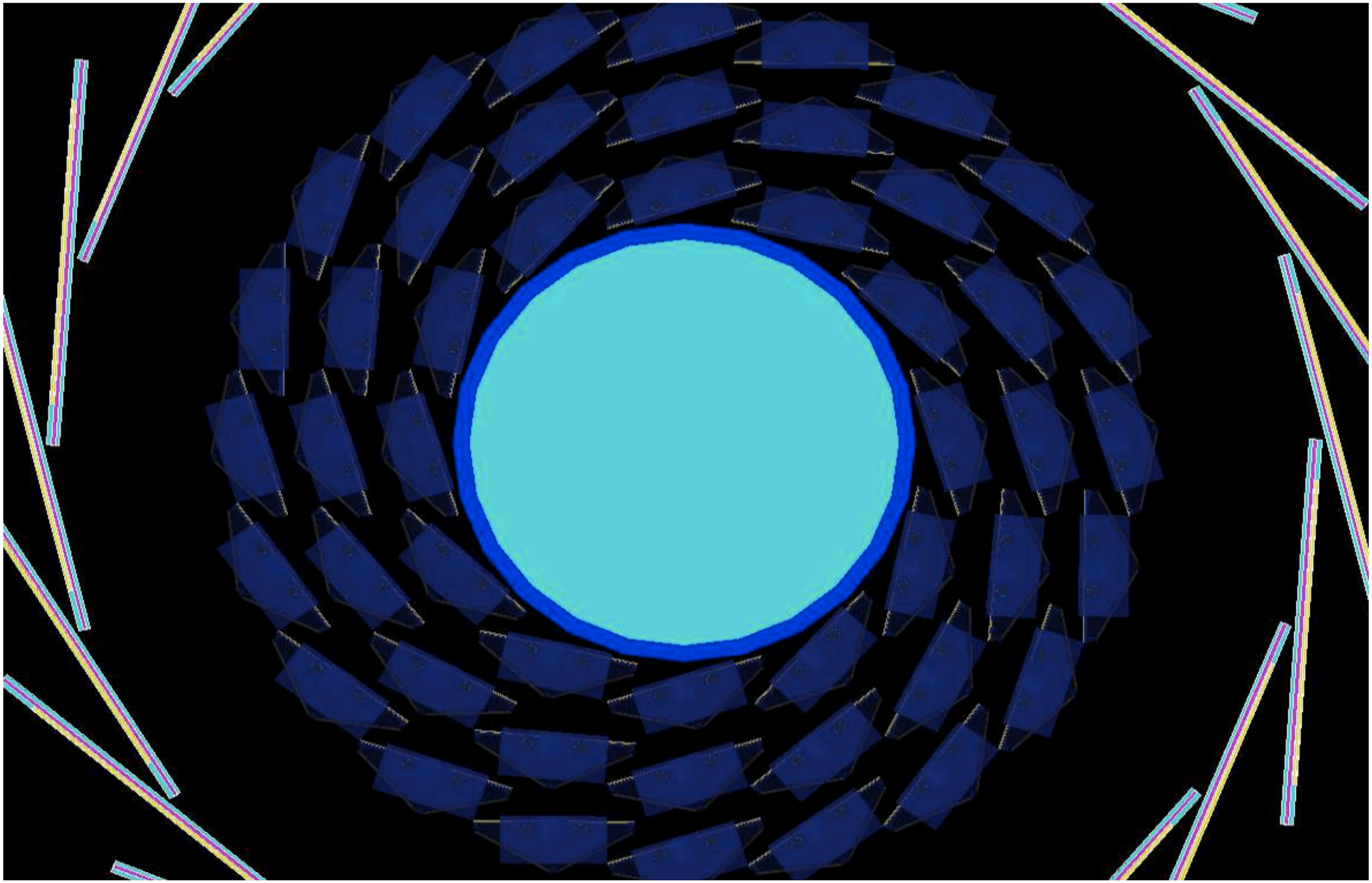
and

1 Y(1S) with
- Realistic p_T distribution
- $-1.0 < y < 1.0$
- Vertex inherited from 100 pion event

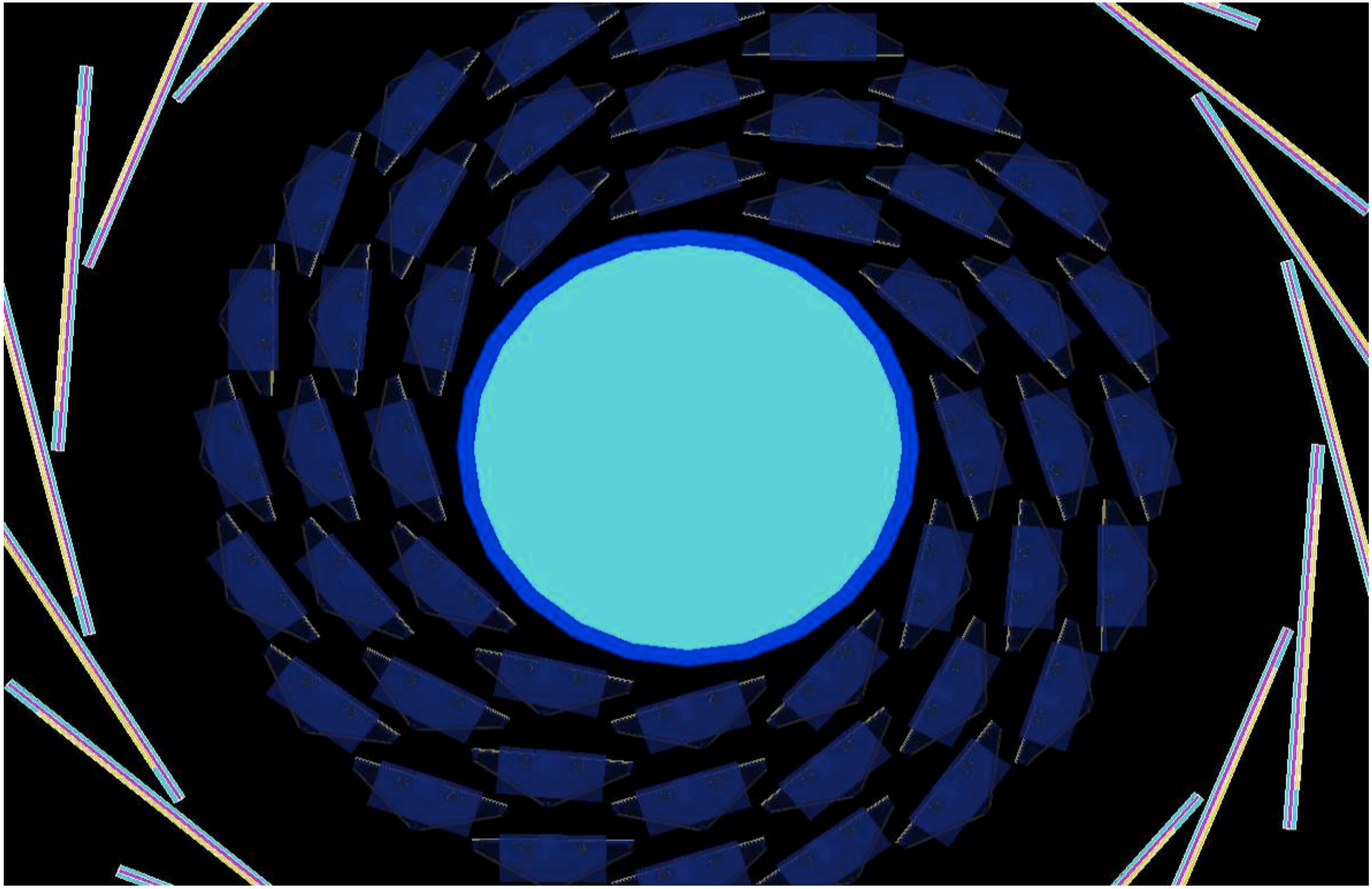
Two MVTX ladder configurations:
Radius 23.4, 31.5, 39.3 mm and tilt 17.4^0
Radius 24.9, 33.0, 40.8 mm and tilt 17.4^0

with INTT ladders and 40 layer TPC.

MVTX radii 23.4, 31.5, 39.3, tilts 17.4^0



MVTX radii 24.9, 33.0, 40.8, tilts 17.4^0



Note

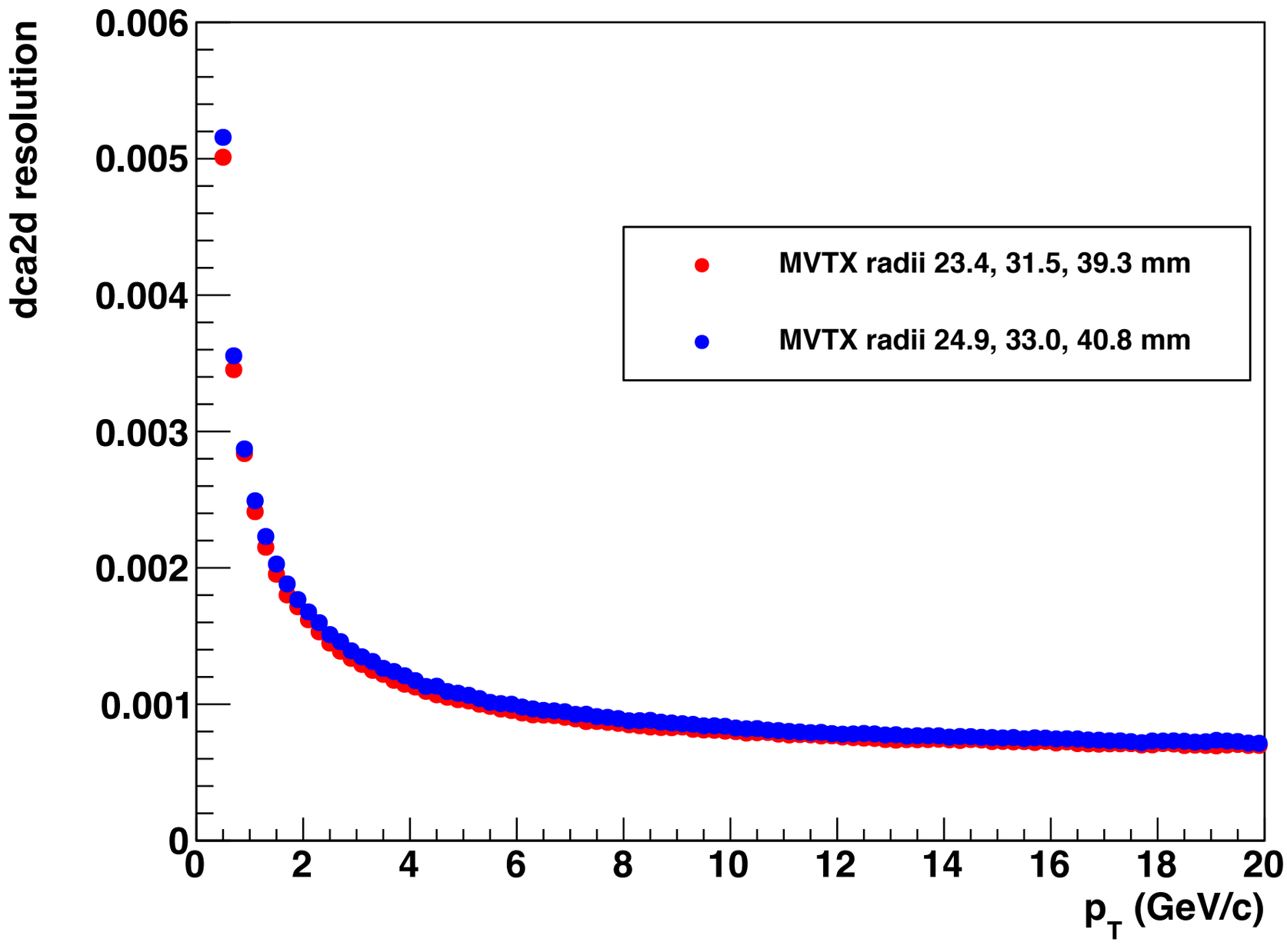
The beam pipe cross section shown in the previous two slides is (I think) the aluminum beam pipe. The Be beam pipe has a smaller outer radius and is hidden behind it.

So I think the actual clearance of the MVTX from the Be beam pipe is larger than it appears in the previous two slides.

Pion dca2d resolution vs p_T

100 pions + 1 Υ into |η| < 1.0

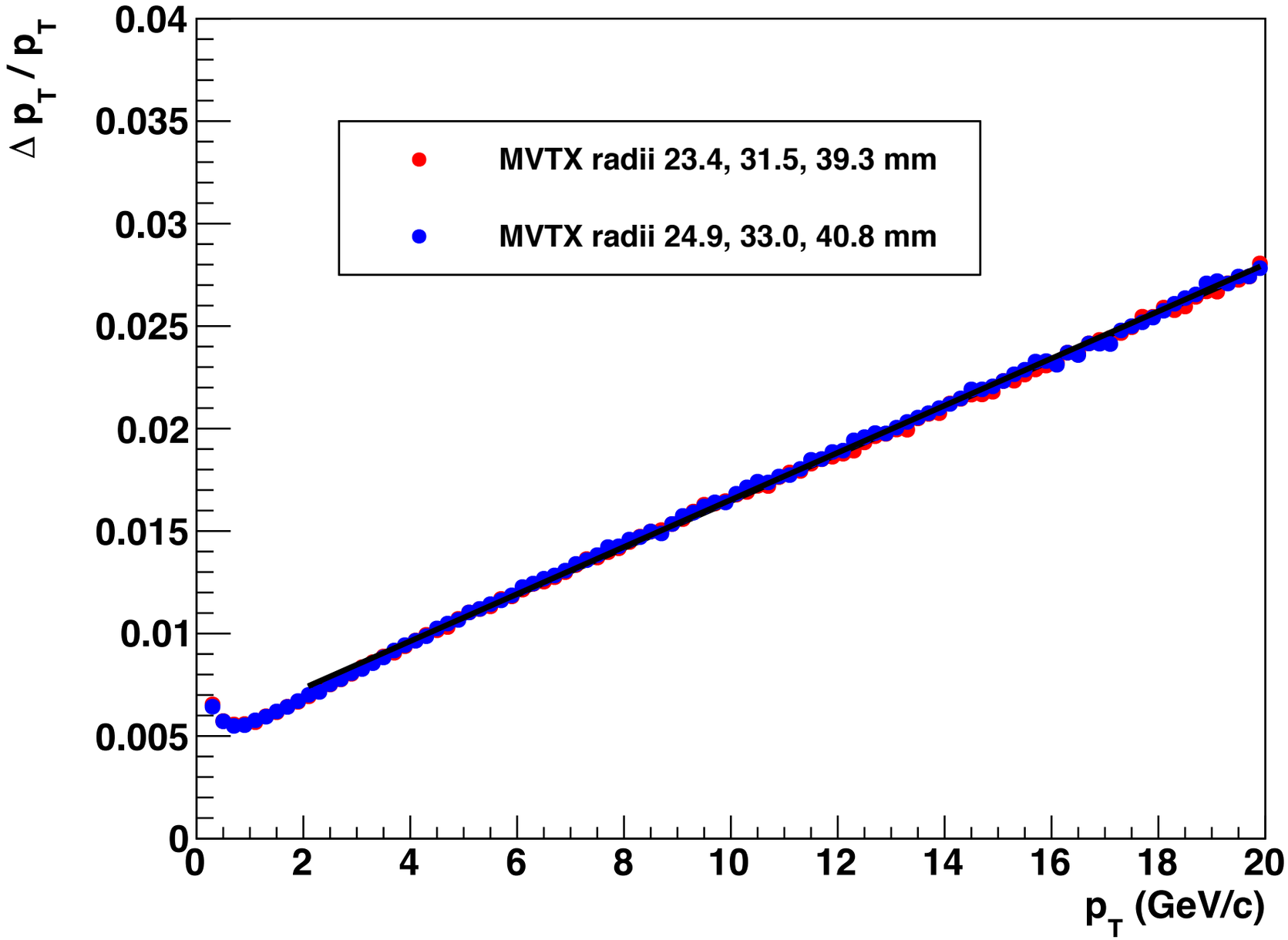
Very small degradation of dca2d resolution



Pion p_T resolution vs p_T

100 pions + 1 Υ into |η| < 1.0

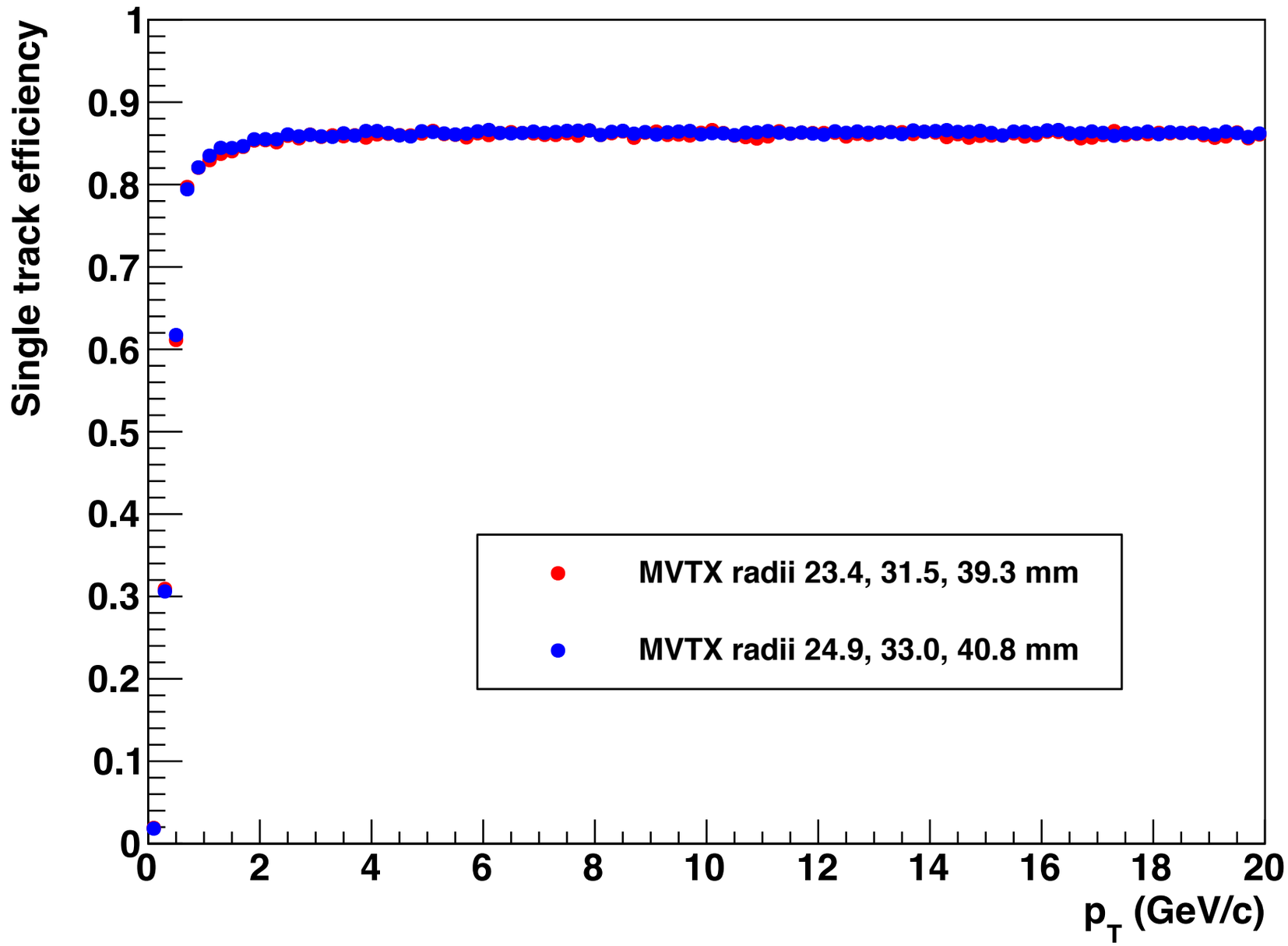
No effect!



Track efficiency vs p_T

100 pions + 1 Υ into |η| < 1.0

No effect!



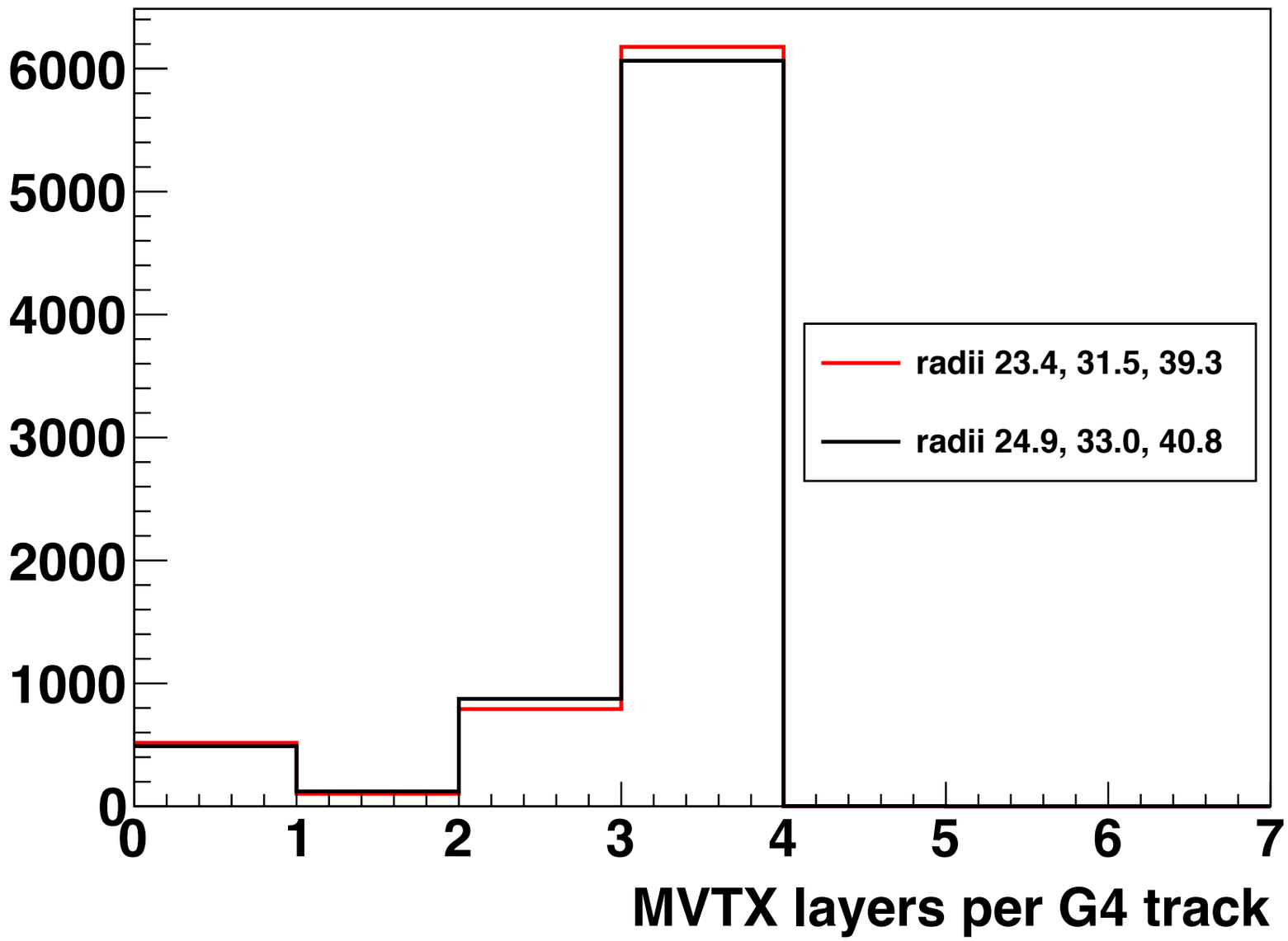
MVTX layers per G4 track

100 pions + 1 Y into |η| < 1.0

Very small increase in G4 tracks hitting 2 layers instead of 3

Note: We are still working on why some G4 tracks have zero MVTX layers associated

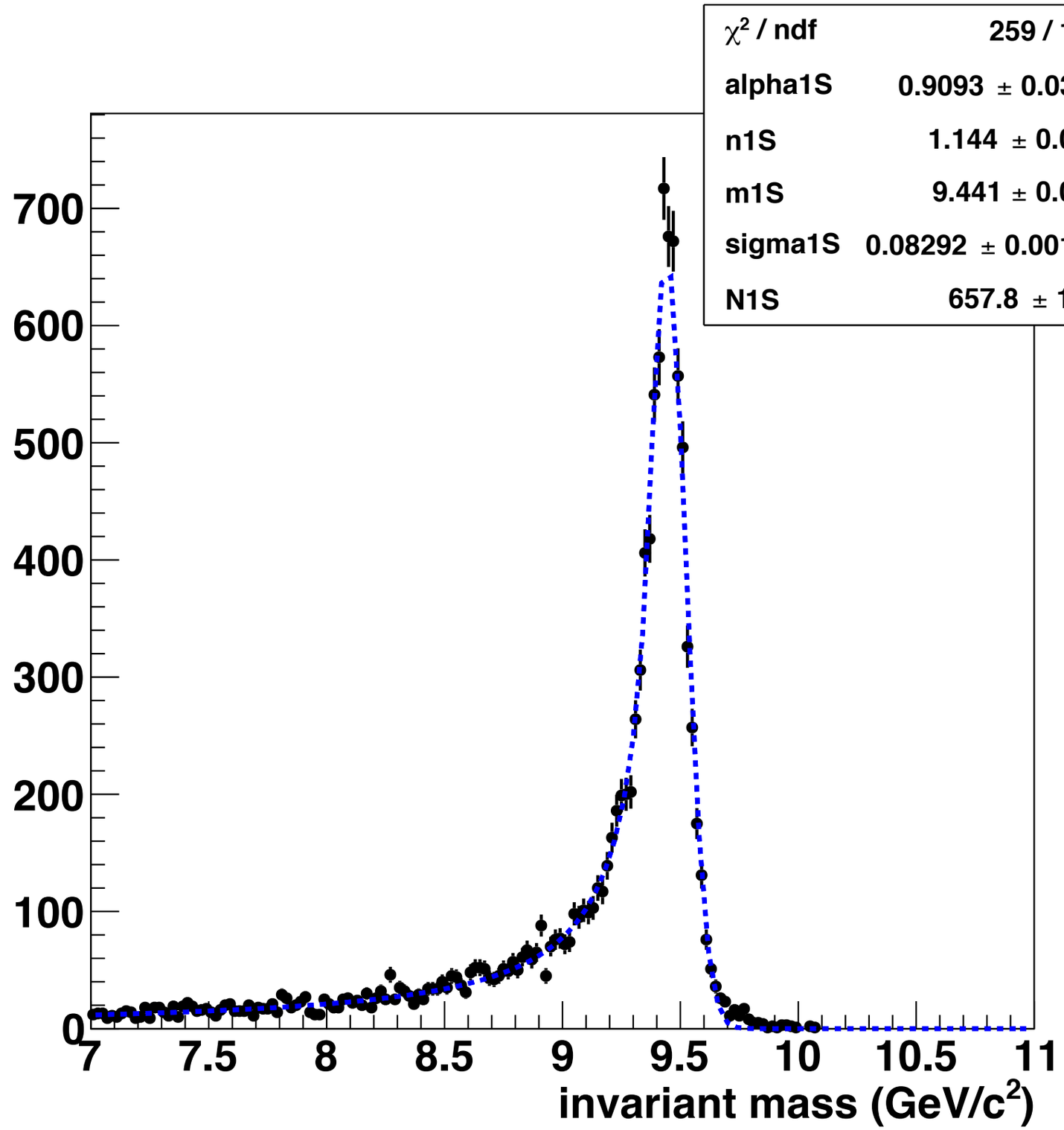
- Tracking, not hardware!



MVTX radii 23.4, 31.5, 39.3, tilts 17.4^0
Y mass spectrum

100 pions + 1 Y
into |η| < 1.0

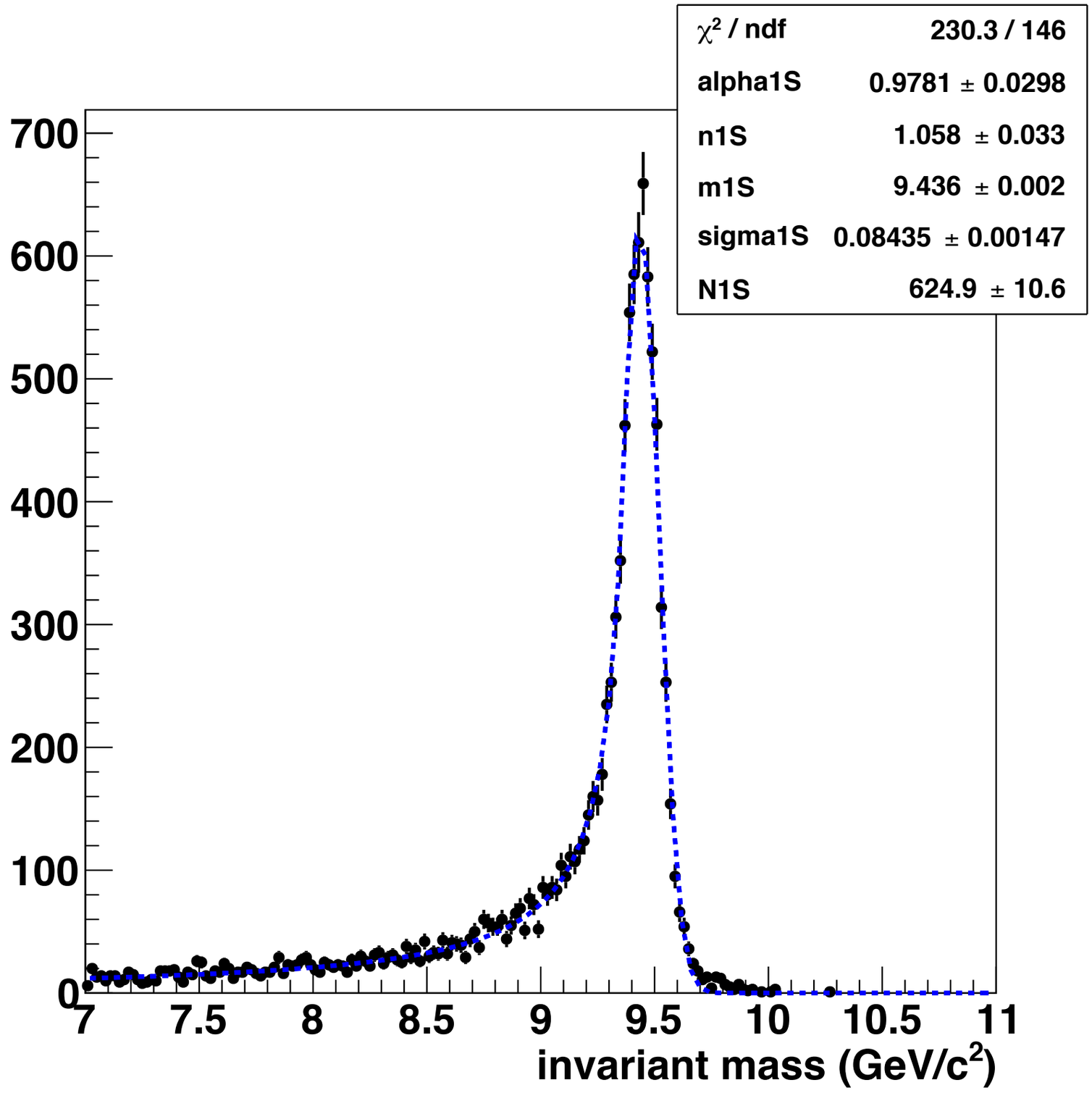
Mass resolution
83 +/- 1.6 MeV



MVTX radii 24.9, 33.0, 40.8, tilts 17.4^0
Y mass spectrum

100 pions + 1 Y
into |η| < 1.0

Mass resolution
84 +/- 1.5 MeV
- no change



Conclusion

Almost no effect on tracking performance of moving the MVTX layers out by 1.5 mm (or less).

- Very small degradation of dca2d resolution
- Small increase in G4 tracks that are associated with 2 layers instead of 3

Related pull requests

Coresoftware PR #324 (PHG4MapsSubsystem, PHG4MapsDetector)

- Allows setting a fixed number of staves in each MVTX layer, independent of radius
- Adjusted minimum azimuthal arc length spacing between staves to better handle the range of radii that sPHENIX is interested in (when stave number is calculated automatically)

Macros PR #67 (G4_Svtx_maps_ladders+intt_ladders +tpc_40layer_KalmanPatRec.C, G4Setup.C, Fun4All)G4_sPHENIX.C)

- The number of MVTX staves per layer can now be fixed in the macro, regardless of the layer radius. Needs coresoftware pull request #324. This is backward compatible, so old macros will still work.
- There are several other changes included in this PR:
  - Option to include primary vertex in track fit
  - TPC layer count is now specified in Fun4All_G4_sPHENIX.C
    - Only G4_Svtx_maps_ladders+intt_ladders+tpc_40layer_KalmanPatRec.C is needed now
  - Re-ordered particle and Upsilon generation to let Upsilons inherit vertex
  - Option to have Upsilons inherit vertex from Hijing or particle generator